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Summary of Newell and Simon Turing Lecture highlighting the main points and conclusions.

The Turing lecture explains the concepts of a physical symbol system, and turing machine, in an effort to better understand the “programmed, living machine”. The article has two main points to discuss, physicl symbol systems, and heuristic search.

The discussion of physical symbol systems begins with a discussion of the laws of qualitative strucre, notably the cell doctrine in biology, plate tectonics in geology, the germ theory of disease, and the doctrine of atomism in chemistry and physics. The idea to take away is that science uses laws of qualitative structure in most (if not all) disciplines, and define how a whole science operates.

Then, the lecture moves into a discussion of physical symbol systems. The two key ideas here are the concepts of designation and interpretation. Designation as defined in the article: “An expression designates an object if, given the expression, the system can either affect the object itself or behave in ways dependent on the object.” The “essence” of designation is “access to the object via expression”. Interpretation as defined in the article: “The system can interpret an expression if the expression designates a process and if, given the expression, the system can carry out the process.” Interpretation is a unique type of designation, in that a system can “evoke and execute its own processes from expressions that designate them”. The physical symbol system hypothesis: “A physical symbol system has the necessary [any system that exhibits general intelligence will prove upon analysis to be a physical symbol system] and sufficient [any physical symbol system of sufficient size can be organized further to exhibit general intelligence] means for general intelligent action [the same scope of intelligence as we see in human action: that in any real situation behavior appropriate to the ends of the system and adaptive to the demands of the environment can occur, within some limits of speed and complexity]”. The lecture states that the physical symbol system hypothesis is clearly a law of qualitative structure, specifying a general class of systems within which one will find those capable of intelligent action. A PSS is an instance of a universal machine, and the PSSH implies that intelligence will be realized by a universal machine. The PSSH also implies that any computation is realizable can be realized by a universal machine, assuming that it is specified. The basis of the hypothesis is rooted in formal logic. A Turing machine is composed of two storage types: an infinite tape, and a finite state control. This concept underlies all existing digital computing systems. The stored program concept is the idea that programs can be data, and operated on as data by other programs, embodying the second half of the interpretation principle, that says the systems own data can be interpreted. List processing arose in ‘56, with the idea that data structures contain symbols, and that these symbols can represent further lists of symbols. List processing created genuine dynamic memory structure for a machine that was thought of having fixed memory, shows that data of any type can be abstracted from the physical machine it exists in, and produced a model of symbol manipulation. LISP completed the model of abstraction ('60), creating a new formal system with s-expressions, which could be shown to be equivalent to other universal schemes of computation. The article also suggests that the PSSH implies symbolic behavior in humans is because humans have the characteristics of PSS.

The lecture then goes on to talk about heuristic search. It defines the heuristic search hypothesis: The solutions to problems are represented as symbol structures. A physical symbol system exercises its intelligence in problem solving by search – that is, by generating and progressively modifying symbol structures until it produces a solution structure. Much of the work with artificial intelligence focuses around problem solving, because that is how we define something as intelligent: its ability to solve problems. Physical symbol systems struggle with generalized problem solving – Plato found difficulty with how problems could be understood, much less solved: "Meno: And how will you inquire, Socrates, into that which you know not? What will you put forth as the subject of inquiry? And if you find what you want, how will you ever know that this is what you do not know?". To deal with this, Plato came up with his theory of recollection, framed in the article as: "To state a problem is to designate a (1) test for a class of symbol structures (solution to a problem), and (2) a generator of symbol structures (potential solutions). To solve a problem is to generate a structure, using (2), that satisfies the test of (1)." The problem with solving problems is search, and most AI work was concerned with search itself, and various methods of doing it. Then, the idea of search trees is presented, with each possible outcome as a branch from a piece of information (chess playing robots/computers use trees with millions of branches). The goal of intelligence is to narrow down the possibilities presented with a huge search tree, "avert[ing] the ever present threaf of the exponential explosion of search". One step is to limit branching to "plausible" solutions, but this only slows down branching, instead of preventing it. With heuristic search, the question is always "what shall be done next", in tree searches represented as "which node" and "which way from that node". Methods that control branching are considered "weak" methods. There are three ways (covered in the lecture) to exemplify "intelligence without much search": nonlocal use of infomation, semantic recognition systems, and selecting appropriate conclusions.